



# Desert PV Module Workshop

## 9-10 May 2017, Doha, Qatar



Operating conditions of PV modules in the Middle East are harsh, with severe temperatures, humidity, UV and dust. Historically PV modules and test standards have been designed for the main PV markets of Europe, US and Asia, where operating conditions are more benign. Now, gigawatts of PV are being deployed in the Middle East. It is imperative to design PV systems suited for desert conditions.

The Desert PV Module workshop is designed to provide solar-energy scientists and stakeholders with understanding of the performance, reliability and testing issues facing PV systems in desert conditions, and opportunities for developing desert-specific technologies.

The event is jointly hosted by:



**Qatar Environment and Energy Research Institute, HBKU**

**Texas A&M University at Qatar**

**Anhalt University of Applied Sciences**

**Fraunhofer Center for Silicon Photovoltaics**

**GÜNAM Middle East Technical University**

**Institut de Recherche en Energie Solaire et en Energies Nouvelles**



The workshop is funded by QNRF, QEERI and TAMUQ, and is supported by the International Solar Energy Society.



9-10 May 2017

HBKU Student Centre, Ballrooms 2&3, Education City, Doha, Qatar

Registration: Ms. Annie Mathew, [amathew@hbku.edu.qa](mailto:amathew@hbku.edu.qa)

# Program

## Day 1, 9<sup>th</sup> May

8:30	Registration			
9:00	Marwan Kraisheh	Acting Executive Director	QEERI	Welcome
9:15	César Malavé	Dean	TAMUQ	Remarks
9:30			QNRF	Remarks
9:45	Jörg Bagdahn	President	Anhalt University of Applied Sciences	Modules for desert climates: challenges for new materials
10:10	Raşit Turan	Professor in Physics	GÜNAM	Recent advances in crystalline Si solar cell technologies and GÜNAM's perspectives
10:35	Coffee break			
10:50	Holger Neuhaus	Managing Director	SolarWorld Innovations GmbH	Bifacial technologies
11:15	Max Köntopp	Director - R&D	Hanwa Q-Cells	Ensuring long term durability and superior energy yield of high efficiency solar modules in harsh climates
11:40	Matthias Ebert	Head of Group - Reliability of Solar Modules and Systems	Fraunhofer CSP	Fatigue analysis of solar cell interconnectors
12:05	Lunch			
13:05	Yong Sheng Khoo	Head of PV Module Development Group	Solar Energy Research Institute of Singapore	Design principles for double-glass bifacial PV module
13:30	Kris Baert	Industrial Research Manager	KU Leuven	Seamless integration of desert PV
13:55	Thomas Studer		Saudi Aramco	Component lifetime and PV economics
14:20	Poster tour & coffee break			
14:50	Bulent Akinoglu	Professor	GÜNAM	GÜNAM's Outdoor PV Test Facility, recent research results and future prospects
15:15	Amir Abdallah	Scientist	QEERI	Results of monitoring of desert modules
15:40	Aboubakr Benazzouz	TBA	IRESEN	Outdoor performance evaluation of different PV technologies in the desert conditions
16:05	End Day 1			
19:00	Dinner			

# Program

## Day 2, 10<sup>th</sup> May

8:45	Opening			
9:00	Bing Guo	Assistant Professor	TAMUQ	PV soiling and development of a dust-shield technology
9:25	Hiroyuki Kawamoto	Professor	Waseda University	Practical performance of electrostatic cleaning system for removal of sand from solar panels
9:50	Christan Hagendorf	Group Manager Diagnostics of Solar Cells	Fraunhofer CSP	Indoor and outdoor soiling testing - investigation at a microstructural level
10:15	Jennifer Chessnut	Postdoctoral Fellow	University of Florida	Microscale mechanisms of electrodynamic mitigation of desert dust on PV panels by computational simulation
10:40	Coffee break			
10:55	Lin Simpson	Senior Scientist	NREL	Soiling mechanisms on PV modules
11:20	Nicoleta Hickman	Associate Professor of Physics	Florida Polytechnic University	Ink printing of graphene nanoflake highly conductive electrodes for dust mitigation technology
11:45	Sandeepan Balan Sobhana	Postdoctoral Research Associate	TAMUQ	Short-term high-resolution modeling of winds in Qatar
12:10	Lunch			
13:10	Said Ahzi	Research Director, Acting	QEERI	Simulation and modeling of PV panels in Qatar's climate
13:35	Holger Neuhaus	Managing Director	SolarWorld Innovations	Aging of glass/glass modules
14:00	Philip Pieters	Director Business Development	imec	High efficiency bifacial silicon solar cell technology and its use for desert applications
14:25	Coffee break			
14:55	Ahmed Alami Merrouni		IRESEN	Outdoor operating temperature modeling of PV modules: Case of GEP
15:20	Hamed Hanifi	Scientist	Fraunhofer CSP	Solar module design with partial cells for desert regions
15:45	David Daßler	Scientist	Fraunhofer CSP	Modeling and outdoor investigation of bifacial modules
16:10	Round-table discussion			
16:55	Conclusions			

# Speakers



**Dr. Marwan K. Kraisheh**  
Senior Research Director  
Executive Director, Acting  
Qatar Environment & Energy Research Institute

Dr. Khraisheh is A Senior Research Director and the Acting Executive Director at Qatar Environment and Energy Research Institute (QEERI). He joined QEERI in January 2014. QEERI is one of three national-oriented research institutes within Hamad Bin Khalifa University (HBKU) at Qatar Foundation. Prior to joining Qatar Foundation, Dr. Khraisheh was the Founding Dean of Masdar Institute of Science and Technology and a member of the MIT-Masdar Joint Executive Committee. He also served as the Acting Provost of Masdar Institute. Prior to joining Masdar Institute, Dr. Khraisheh was an Endowed Professor at the Department of Mechanical Engineering at the University of Kentucky. Dr. Khraisheh is a recipient of a number of awards including the US National Science Foundation CAREER Award. He is a Fellow of the American Society of Mechanical Engineers (ASME), a Fellow of the American Association for the Advancement of Science (AAAS) and a Member of the International Academy of Production Engineering (CIRP). He serves as the Associate Technical Editor of the ASME Transactions Journal of Engineering Materials and Technology and also as the Associate Editor of the new International Energy Transitions Journal published by Springer.



**Dr. César Malavé**  
Dean  
Texas A&M University at Qatar

Dr. César Malavé is dean and professor in the Chemical Engineering Program at Texas A&M University at Qatar. He was previously professor and department head of Industrial and Systems Engineering at Texas A&M University and holder of the Sugar and Mike Barnes Department Head Chair. Under his leadership the department recruited a number of new faculty at both the junior and senior levels, developed a new advanced manufacturing initiative, and launched major initiatives to revamp the undergraduate curriculum and graduate program. His major career accomplishments are in the areas of manufacturing systems analysis; engineering education innovation, and diversity development for engineering faculty and undergraduate student programs. He has been the principal investigator (PI) or coprincipal investigator (Co-PI) of more than \$35 million in sponsored research and academic projects.



**Dr. Jörg Bagdahn**  
President  
Anhalt University of Applied Sciences, Germany

Jörg Bagdahn is the president of the Anhalt University of Applied Sciences since September 2016 and has a professorship for "Photovoltaic Materials" at the University. Jörg Bagdahn holds a diploma and a Ph. D. in material science from the Technical University of Chemnitz and Martin-Luther-University Halle, respectively. From 2000 until 2002 he worked as a postdoctoral fellow at the Johns Hopkins University on long term reliability of thin silicon films for MEMS applications. In 2003 he joined Fraunhofer and was responsible for various research activities in the area of microsystem technology, microelectronics and photovoltaics. From 2007-2016 he was the director of the Fraunhofer Center for Silicon Photovoltaics CSP.

# Speakers



**Dr. Raşit Turan**  
Professor in Physics  
Center for Solar Energy Research and Applications (GÜNAM), Turkey

Raşit Turan completed B. Sc. and M. Sc. degrees at the Physics Department of Middle East Technical University (METU), Turkey. He received his Ph.D degree from University of Oslo, Norway in 1990. He worked as Post. Doc. at Linköping University, Sweden. He joined METU Physics Department as faculty member in 1991. He worked as a visiting scientist at the Material Science Department of Toronto University, Canada in 1996. His main research interests have been physics and technology of semiconductor materials and devices including solar cells. He has published more than 160 scientific papers in this field in the internationally recognized journals. He has supervised 7 Ph.D. and about 20 M.Sc. studies. Raşit Turan has coordinated many national and international projects. Among them, European FP6 projects SEMINANO, and METU-CENTER have been among the largest research and support projects coordinated by Dr. Turan. In 2009, he founded a new research center called Center for Solar Energy Research and Applications (GÜNAM) on METU campus. GÜNAM has attracted nationwide and international attention. Recently, a national solar energy system development project, called MILGES, been given to the consortium where GÜNAM is a key member for solar cell development. He is one of the partners of the project called "PV Smart Skin" conducted by Texas A&M Doha, and supported by QNRF of Qatar.



**Dr. Holger Neuhaus**  
Managing Director  
SolarWorld Innovations, Germany

Dr Neuhaus obtained his physics degree in 1998 and completed his PhD in 2002. He has more than 15 years of international experience in the solar industry, Solar Cell Characterization Engineer at Pacific Solar, Head of Quality Assurance and Technology at SolarWorld. He joined SolarWorld in 2003, and has served as Managing Director since 2009.



**Dr. Max Köntopp**  
Director R&D  
Hanwa Q-Cells, Germany

Dr. Max B. Koentopp received his Ph.D. in physics from Karlsruhe Institute of Technology (KIT) in 2005. After Postdoctoral positions at Rutgers University, Columbia University, and Princeton University, he joined the R&D team of Hanwha Q CELLS in 2009 as a project manager and simulation expert. As Director of the Analysis & Modeling department, he is currently responsible for global module reliability testing, cell and module characterization, global test sites, production calibration chains, device modeling and simulation. His experience includes PV module reliability and certification, solar cell characterisation, and modeling of device performance. He has over 15 years of experience in modeling and simulation.

# Speakers



**Dr. Matthias Ebert**  
Head of Group – Reliability of Solar Modules and Systems  
Fraunhofer Centre for Silicon Photovoltaics, Germany

Dr. Matthias Ebert is the head of group " Reliability of Solar Modules and Systems " at Fraunhofer Center for Silicon Photovoltaics (CSP) in Halle (Saale), Germany. He studied Civil Engineering at Bauhaus University Weimar, Germany. He obtained his Ph.D. in the field of stochastic structural mechanics at the Institute for Structural Mechanics in Weimar in 2002. He has been working at Fraunhofer in Halle since 2003. At first he worked at Fraunhofer Institute of Mechanics of Materials in the field of the mechanics and testing of microstructures. Matthias Ebert has been working in the field of photovoltaic since 2007. The group investigates the reliability of modules, components and materials by material testing, thermomechanical Finite- Element Modelling and accelerated testing methods.



**Dr. Khoo Yong Sheng**  
Head of PV Module Development Group  
Solar Energy Research Institute of Singapore

Dr. Yong Sheng KHOO is the head of the PV Module Development group at the Solar Energy Research Institute of Singapore (SERIS). Yong Sheng has more than 6 years of experience in PV module development and testing. He was instrumental in setting up the first outdoor potential-induced-degradation (PID) test facility in Singapore. His research work over the years have covered important areas of PV technological development such as investigating outdoor performance of different module technologies in Singapore, modelling of optimal PV module orientation and tilt angle for maximum energy collection by the module, development of novel optical characterisation techniques for PV modules, optimising the performance of PV modules for tropical conditions, and investigation of new module processing technology. His current work focuses on study of module PID, improving module power output, and reducing module production cost through novel fabrication process. His latest development features a double-glass bifacial PV module with superior front and rear side performance that can produce additional energy by capturing light from both sides of a module. Yong Sheng obtained his Ph.D. degree from the Graduate School for Integrative Science and Engineering at the National University of Singapore (NUS) while working as post-graduate researcher at SERIS. He also holds a B.S (Magna cum Laude) and M.Eng degree in Mechanical & Aerospace Engineering from Cornell University, USA.

# Speakers



Prof. Dr. Bulent G. Akinoglu  
METU Dept. of Physics  
Center for Solar Energy Research and Applications (GÜNAM), Turkey

Dr. Akinoglu is a physicist in Department of Physics, Middle East Technical University, Ankara-Turkey. He is also affiliated by Earth System Science Department (ESS-METU) and also a member of GUNAM (Center for Solar Energy Research and Application-METU). Dr. Akinoglu is co-founder of ESS and ISES Turkish Branch. He is also co-founder of NGOs in Turkey who works on energy and environmental issues. He participated in many international and national conferences and published around 80 articles and a book chapter. Dr. Akinoglu established a crystal growth laboratory in Physics Department and worked in this laboratory many years with his students on the material science aspects while in the meantime he continued to study on solar energy, physical modeling of solar irradiation reaching the Earth, and energy and environment issues. He developed courses on Solar Energy, Physics of Solar Energy and Physics of Energy topics and he is opening these courses every semester; many students take these courses from science and engineering departments. At present he is acting as the coordinator of GUNAM Outdoor PV Test Facility. He is currently working on determining the countrywide solar irradiation prediction schemes, energy efficient houses, long and short term PV module and array performance calculations, paleo estimation of solar irradiation, sustainable development and sustainable energy policy issues.



Dr. Amir Abdallah  
Scientist  
Qatar Environment & Energy Research Institute

After completing his MSc. in Mechanical Engineering from Delft University of Technology (The Netherlands) he obtained in 2007 his PhD in Material Science from Eindhoven University of Technology, Eindhoven (The Netherlands). Dr. Abdallah has industrial experience in fabrication of silicon solar cells. This includes process optimization and characterization. In addition, he gained experience in tackling the electronic properties of amorphous silicon thin film solar cells. As a scientist at Qatar Environment & Energy Research Institute (QEERI) since 2014, Dr. Abdallah is coordinating the project activities in Photovoltaic module performance and reliability. This includes power losses due to soiling and high operating temperature and module degradation. Besides, he is contributing to the development of silicon heterojunction solar cell within QEERI.



Kris Baert  
Industrial Research Manager  
KU Leuven / EnergyVille, Belgium

Kris Baert is an Industrial Research Manager at KU Leuven / EnergyVille (Belgium) with a 30 year track record of technological innovation in Smart Energy, Photovoltaics and Microsystems. Before joining EnergyVille he worked for Mitsubishi Electric (Japan) and imec (Belgium). His experience includes multi-partner R&D projects, IP portfolio build up, acquisition of public & industrial funding, project definition and management, financial and technical reporting. He is (co-)author of >260 publications and >10 patents. Currently he is responsible for EnergyVille's research valorisation in the domain of Electrical Systems.



# Speakers



Thomas Studer  
Renewable Energy Project Engineer  
Saudi Aramco, Saudi Arabia

Thomas Studer holds a master's degree in materials science and engineering from EPFL in Switzerland. He has more than 10 years professional experience in the solar field. His career has led him through a CIGS startup company, a thin film silicon turn-key factory supplier, where he was responsible for the process integration and ramp-up of production at the client site. He moved on to become the lead engineer of a thin film factory in Spain. Since 2012 he is working as a renewable energy expert for Saudi Aramco.



Dr. Bing Guo  
Assistant Professor  
Texas A&M University at Qatar

Dr. Bing Guo is Assistant Professor of Mechanical Engineering at Texas A&M University at Qatar. His current research interest is in photovoltaic soiling and mitigation. Dr. Guo's previous research has involved neural network modeling of gasification, aerosol formation in flames, nanomaterial synthesis, health effects of nanoparticles, aerosol sampling system design, CFD modeling of aerosol transport. He has also been a consultant on stack sampling representativeness for nuclear power the nuclear power industry. Dr. Guo has over 30 peer-reviewed journal publications and a number of conference papers. Dr. Guo received his bachelor's, master's and doctoral degrees from Tsinghua University.



Dr. Hiroyuki Kawamoto  
Professor  
Waseda University, Japan

Hiroyuki Kawamoto holds a BS degree in Electrical Engineering from Hiroshima University and a Dr. degree in Mechanical Engineering from Tokyo Institute of Technology. He used to be a Senior Engineer at Hitachi Ltd and a research fellow at Fuji Xerox. From 1999 he has been a professor of Waseda University in Tokyo. His primary research focus is dynamics of electromagnetic particles and its application for space exploration.



Dr. Christian Hagendorf  
Group Manager Diagnostics of Solar Cells  
Fraunhofer Centre for Silicon Photovoltaics, Germany

Dr. Christian Hagendorf is head of the research group "Diagnostics of Solar Cells" at Fraunhofer Center for Silicon Photovoltaics CSP, Germany. He obtained his PhD at Martin-Luther-University Halle-Wittenberg, Germany in the field of surface and interface analysis of semiconductor materials. He joined Fraunhofer CSP in 2007 and established a research group focussed on defect diagnostics in crystalline and thin film photovoltaics. Advanced research activities are dealing with material scientific issues in solar cells and modules. The impact of microstructural, optical and electrical material properties on yield and performance is studied and implemented for the advancement in PV metrology solutions.



# Speakers



Dr. Jennifer Chessnut  
Postdoctoral Fellow  
University of Florida, USA

Jennifer K. W. Chesnutt received her B.S. degree in applied mathematics from Florida State University, Tallahassee, FL, USA, M.S. degree in agronomy from University of Nebraska-Lincoln, Lincoln, NE, USA, and Ph.D. degree in mechanical engineering from The University of Iowa, Iowa City, IA, USA. She trained as a Postdoctoral Research Fellow with the School of Engineering at The University of Vermont, Burlington, VT, USA (2009-2010) and with the Department of Mechanical Engineering at The University of Texas at San Antonio, San Antonio, TX, USA (2010-2015), in joint collaboration with The University of Texas Health Science Center at San Antonio, San Antonio, TX, USA (2010-2013). Currently, she is a Postdoctoral Associate with the Department of Environmental Engineering Sciences at the University of Florida, Gainesville, FL, USA (2015-present). Dr. Chesnutt is a recipient of a Ruth L. Kirschstein National Research Service Award (T32) from the National Institutes of Health (2010-2013). She is a member of ASME (2009-present) and a previous member of the Biomedical Engineering Society (2010-2016), the American Physical Society (2004-2013), and the American Heart Association (2012-2013). Her current research interests include computational modeling of adhesive particulate flows, specifically to address applications of electrostatics to mitigate dust on photovoltaic panels and concentrating solar power reflectors.



Dr. Lin Simpson  
Senior Scientist  
National Renewable Energy Laboratory, USA

Dr. Simpson has a broad background in research, development, and program management. He presently leads efforts on soiling of PV modules, passive cooling for PV modules, and improving PV modules to lower the levelized cost of energy. In general, Dr. Simpson has extensive experience in surface science, nanotechnology, materials science, and physics. At NREL, he performs advanced technology deployment, technology evaluation, and leads efforts on photovoltaics (PV), advanced insulation, and hydrogen storage. Dr. Simpson performs advanced materials development and testing for a number of applications including: photovoltaics, batteries, insulation, fuel cells, catalysts, electrochromics, and energy related technologies. Previously, he was the director for DOE's Hydrogen Sorption Center of Excellence, developing advanced hydrogen storage materials and system. Prior to joining NREL, Dr. Simpson was the Manager of Advanced Programs at ITN Energy Systems, Inc., where he planned, implemented, and managed R&D activities to produce the next generation of enabling technologies for a broad range of commercial applications in technology areas that included: nanomaterials, nanotechnology, thin-film photovoltaics, thin-film processing, fuel cells, electrochromics, and solid-state batteries, advanced sensors. Dr. Simpson was also a Research Scientist in the Chemical Technology Division at Argonne National Laboratory, where he evaluated the structural and chemical integrity of materials and performed mechanistic investigations using electrochemical and optical techniques. Dr. Simpson has over 25 years experience in successful energy related R&D activities including: fundamental academic studies involving modeling, applied research at national laboratories, and directing intellectual property/commercial product development and system integration in industry. These efforts have led to over 50 scientific publications and patents. Dr. Simpson is interested in performing a variety of R&D activities involving materials science, nanostructures, engineering, and product development.

# Speakers



Dr. Nicoleta Hickman  
Associate Professor of Physics  
Florida Polytechnic University, USA

Dr. Nicoleta Hickman is an Associate Professor of Physics in the College of Innovation & Technology, where she has been a faculty member since 2015. Prior to joining Florida Poly, she was an Associate Professor in the Thermoelectric and Photovoltaic Hybrid Laboratory at the Florida Solar Energy Center at UCF, Orlando. Dr. Hickman completed her Ph.D. and her master's degree in Physics at Clemson University. She holds a master's degree and bachelor's degree in Physics from at "Al. I. Cuza" University in Romania. Her major research interest is in photovoltaic and thermoelectric materials and devices. The interdisciplinary philosophy of research within her lab combines the disciplines of physics, nanotechnology, materials science, chemistry and electrical engineering leading toward attractive research opportunities. The background of students and researchers within the lab reflect this breadth, and as a result, the laboratory is vertically integrated in its activities, straddling from basic to applied research.



Sandeepan Balan Sobhana  
Postdoctoral Research Associate  
Texas A&M University at Qatar

Sandeepan B. S. is currently working as postdoctoral research associate on the NPRP project: Multi-scale Modeling of Hydrodynamics in Arabian Gulf with Professor Vijay Panchang. He received a B.Sc. in Physics from Kannur University (India), an M.Sc. in Meteorology from Cochin University of Science and Technology, and a Ph.D. from the Indira Gandhi Center for Atomic Research. Subsequently he worked as a project scientist at the National Center for Medium Range Weather Forecast in New Delhi. He has several years of experience in boundary layer parameterization for atmospheric models, observational analysis and numerical modeling of atmospheric submesoscale motions, and pollutant dispersion.



Dr. Said Ahzi  
Professor and Acting Research Director  
Qatar Environment & Energy Research Institute

Dr. Said Ahzi is Professor at Hamad Bin Khalifa University and Acting Research Director at Qatar Environmental and Energy Research Institute (QEERI/HBKU). Prior to joining QEERI/HBKU, he held a Distinguished Professor position at the University of Strasbourg – France. Dr. Said Ahzi holds an Adjunct Professor position with the School of Materials Science and Engineering at Georgia Institute of Technology, Atlanta – USA. He also holds an Adjunct Professor position with the Materials Science Department at Texas A&M, College Station - USA. Dr. Ahzi held several other positions with different Universities and research laboratories worldwide. Dr. Said Ahzi research interest include: Multiphysics and multiscale modeling of materials and structures; Microstructure sensitive design of materials; Bridging microstructure, properties and processing; Computational modeling of materials processing and manufacturing; Development of physically-based constitutive laws for thermo-mechanical and physical behavior of heterogeneous materials (metals, polymers, nanocomposites, ...); and Thermal analysis of materials and structures. He advised about 27 PhDs, 25 Masters, was the scientific advisor (guarantor) for six Habitations and mentored several Postdoctors. He published more than 270 scientific papers in the areas of mechanics, materials science and processing.

# Speakers



**Zakaria Naimi**  
Director of PV and Electrical Systems  
Institut de Recherche en Energie Solaire et Energies Nouvelles, Morocco

Mr. Zakaria NAIMI is the Director of PV and electrical systems at IRESEN and the coordinator of the Green Energy Park. He holds an engineering degree in electrical engineering and he's doing his PhD in energy markets forecast. He worked few years ago with the National Grid Operator ONEE as a design engineer where he developed the medium voltage electrical grid's master plan in the south region by 2026. He coordinated the realization of the Green Energy Park "GEP" and he's currently leading national and international research and demonstration projects in PV technologies at the GEP.



**Dr. Philip Pieters**  
Director Business Development  
imec, Belgium

Philip Pieters holds a M.S. degree and a Ph.D. degree in electrical engineering from the University of Leuven, Belgium. Dr. Pieters has been working at imec, an independent electronics research center in Leuven, Belgium, for more than 20 years. He started as a researcher and scientist, and since 2002 he is with the Business Development department. Since 2008 Dr. Pieters is Business Development Director for imec's energy business.



**David Daßler**  
Scientist  
Fraunhofer Centre for Silicon Photovoltaics, Germany

David is a scientist in fields of outdoor yield measurements and evaluation. He has a B.Sc. and M.Sc. in Applied Mathematics from Leipzig University of Applied Sciences, Germany. He was a research assistant at Fraunhofer Center for Silicon Photovoltaics CSP (Group: Reliability of Solar Modules and Systems) from 2012 to 2015, and is currently a Phd Student and scientist at Fraunhofer Center for Silicon Photovoltaics CSP and Anhalt University of Applied Sciences.